

## CLAIMS

1. An adder circuit (70) for summing a plurality of addends from multi-bit words comprising:

a network of n-input carry-save adder circuits (71 ... 76) each having a first number of sum outputs and a second number of carry outputs,

the adder circuits being arranged in a plurality of columns (j), each column corresponding to a predetermined bit position in the sum, and being arranged in a plurality of levels,

the first level receiving a number of addends from corresponding bit positions of selected ones of the plurality of words and

the lower levels each receiving addends from one or more of (i) corresponding bit positions of other selected ones of the plurality of words, (ii) sum outputs from a higher level adder circuit in the same column, and (iii) carry outputs from a higher level adder circuit in a column corresponding to a less significant bit position,

wherein the number of n-input adders in each column varies according to the bit position.

2. The circuit of claim 1 in which the number of n-input adders in each column is specifically adapted to the number of addends required for that column.

3. The circuit of claim 1 in which the number of n-input adders in each bit position of the first level does not exceed the integer part of the number of addends divided by n.

4. The circuit of claim 1 or claim 4 in which the number of n-input adders in each bit position of the lower levels does not exceed the integer part of:

the total of: (a) the number of sum outputs of the n-input adders in a higher level and the same column, (b) the number of unconnected inputs from

a higher level and the same column, and (c) the number of carry outputs from a higher level and a column corresponding to a less significant bit position, which total is divided by  $n$ .

5           5.       The circuit of claim 4 in which the number of unconnected inputs is that of the immediate higher level.

          6.       The circuit of claim 4 in which the number of sum outputs is that of the immediate higher level.

10

          7.       The circuit of claim 4 in which the number of carry outputs is that of the immediate higher level.

          8.       The circuit of claim 1 in which  $n$  is three, the first number of sum  
15       outputs is two and the second number of carry outputs is two.

          9.       The circuit of claim 1 further including means for delivering each one of the plurality of multi-bit words to the network of  $n$ -input adders such that the number of addends per bit position varies as a function of bit position.

20

          10.      The circuit of claim 1 or claim 4 further including one or more ( $n-1$ )-input adders placed at selected positions within the network.

          11.      The circuit of claim 10 in which the selected positions are  
25       determined so as to reduce the number of levels required to sum the plurality of addends.

          12.      The circuit of claim 11 in which the  $n$ -input adders are three-input adders, the ( $n-1$ )-input adders are two-input adders, and in which each  
30       selected position is determined according to an identified bit position and level where the number of outputs would otherwise be greater than two, the

selected position being at a level above the identified position and in the same bit position.

13. An adder circuit (80) comprising:
- 5 an input for receiving a plurality of addends;
- first summation means (81...86) for summing a plurality of addends to produce an output (87) comprising a high order part ( $Cc'(78:16)$ ,  $Cs'(78:16)$ ) and a first and second low order part ( $Cc'(15:0)$ ,  $Cs'(15:0)$ );
- a first feedback line (91) for coupling the first high order part to a lower
- 10 order position at said input, for a subsequent calculation;
- an output stage including second summation means (88) for summing the first and second low order parts to provide a first word output (89) and a feedback register (90,  $c''_{16}$ ) for retaining a carry bit from said second summation means and for providing said carry bit as input to said second
- 15 summation means during a subsequent calculation.

14. The adder circuit of claim 13 in which the high order part comprises a sum term and a carry term fed back to a subsequent calculation.

- 20 15. The adder circuit of claim 13 in which the carry bit ( $c''_{16}$ ) is used at the end of a subsequent calculation of the first and second low order parts by the first summation means (81...86).

- 25 16. The adder circuit (80) of claim 13 for summing a plurality of addends from multi-bit words in which:

the first summation means comprises a network of carry-save adder circuits (81...86) each having a number of inputs, a number of sum outputs and a number of carry outputs,

- 30 the adder circuits being arranged in a plurality of columns, each column corresponding to a predetermined bit position in the sum, and being arranged in a plurality of levels (81 ... 86),

the first level (81) coupled for receiving a number of addends from corresponding bit positions of selected ones of the plurality of words and

the lower levels (82 ... 86) coupled for receiving addends from one or more of (i) corresponding bit positions of other selected ones of the plurality of words, (ii) sum outputs from a higher level adder circuit in the same column, and (iii) carry outputs from a higher level adder circuit in a column corresponding to a less significant bit position,

the first feedback line (91) coupling a first plurality of more significant bit outputs (87) of the lowest level (86) adder circuits, as said first high order part, to a corresponding number of less significant bit inputs of said first level of adder circuits at said lower order position.

17. The adder circuit of claim 13 or claim 15 in which the high order part comprises a high order carry term output and a high order sum term output, and in which the first low order part comprises a low order carry term output and the second low order part comprises a low order sum term output.

18. A pipelined adder circuit (180) for summing a plurality of addends from multi-bit words comprising:

first summation means (181...187) comprising a network of carry-save adder circuits, the adder circuits being arranged in a plurality of columns, each column corresponding to a predetermined bit position in the sum, and being arranged in a plurality of levels (181...187), the first level (181) coupled for receiving a number of addends from corresponding bit positions of selected ones of the plurality of words and the lower levels coupled for receiving addends from one or more of (i) corresponding bit positions of other selected ones of the plurality of words, (ii) sum outputs from a higher level adder circuit in the same column, and (iii) carry outputs from a higher level adder circuit in a column corresponding to a less significant bit position,

a first feedback line (191) for coupling a first plurality of more significant bit outputs of the lowest level (187) adder circuits to a corresponding number of less significant bit inputs of an intermediate level (185) of adder circuits for a

subsequent calculation, the intermediate level being between said first and lowest level adder circuits.

19. The pipelined adder circuit of claim 18 further including an output  
5 stage including second summation means for summing first and second low  
order parts respectively comprising a second and a third plurality of less  
significant bit outputs of the lowest level adder circuits to provide a first word  
output and a feedback register for retaining a carry bit from said second  
summation means and for providing said carry bit as input to said second  
10 summation means during a subsequent calculation.

20. Apparatus substantially as described herein with reference to the  
accompanying drawings, figures 5 to 11.